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(54) **MEDIA ITEM VALIDATION**

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G06K 9/00	(2006.01)
G07D 7/00	(2006.01)
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G07D 7/12	(2016.01)
G07D 7/20	(2016.01)
G07D 5/00	(2006.01)

(52) **U.S. Cl.**

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USPC 194/206, 207; 209/534; 235/379; 382/134–136

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,437,357 A *	8/1995	Ota	G07D 7/12	
			194/206	
5,485,908 A *	1/1996	Wang	G07D 5/00	
			194/317	
5,542,518 A *	8/1996	Kurosawa	G06K 9/6286	
			194/206	
5,619,620 A *	4/1997	Eccles	G06K 9/66	
			382/158	
5,678,677 A *	10/1997	Baudat	194/206	

(Continued)

FOREIGN PATENT DOCUMENTS

JP 402148383 A * 6/1990 .... 194/207

OTHER PUBLICATIONS

English Translation of JP402148383A.*

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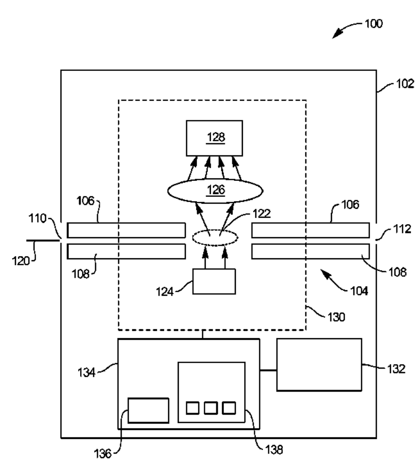
(57) **ABSTRACT**

A method of validating a media item, comprising: for each of a plurality of sensors that sense a media item, determining a respective validation score indicating a likelihood that the sensed media item is valid; and determining if the media item is valid responsive to the plurality of validation scores. Apparatus for validating a media item and a document processing module are also provided.

9 Claims, 3 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

5,796,869	A *	8/1998	Tsuji	G03G 21/046	382/187
5,884,296	A *	3/1999	Nakamura	G06T 7/402	382/155
5,992,600	A *	11/1999	Baudat	G06K 9/6267	194/207
6,157,895	A *	12/2000	Nakajima	G07D 7/168	250/548
6,192,351	B1 *	2/2001	Persaud	G06K 9/00536	382/156
6,236,745	B1 *	5/2001	Chen	G07D 7/00	382/135
6,705,448	B1 *	3/2004	Steel	194/302	
6,990,474	B2 *	1/2006	Woods	G07D 7/185	706/1
7,097,022	B2 *	8/2006	Mukai	G07D 7/2058	194/207
7,856,137	B2 *	12/2010	Yonezawa	G06K 9/00899	194/328
7,913,832	B2 *	3/2011	Voser	G07D 7/00	194/207
8,077,961	B2 *	12/2011	Schmalz	G07D 7/20	382/135
8,086,017	B2 *	12/2011	He	G06K 9/00	356/71
8,503,796	B2 *	8/2013	He	G06K 9/6267	382/224
8,611,665	B2 *	12/2013	He	G06K 9/00	382/181
8,797,516	B2 *	8/2014	Stockli	G07D 7/00	356/71
2002/0043560	A1 *	4/2002	Woods	G07D 7/185	235/438
2003/0150687	A1 *	8/2003	King	194/207	
2004/0084278	A1 *	5/2004	Harris et al.	194/302	
2004/0213448	A1 *	10/2004	Jou	G07D 7/00	382/135
2006/0098859	A1 *	5/2006	Anouar	G07D 7/20	382/135
2006/0254876	A1 *	11/2006	Baudat	194/206	
2010/0116619	A1 *	5/2010	Jones	194/217	

* cited by examiner

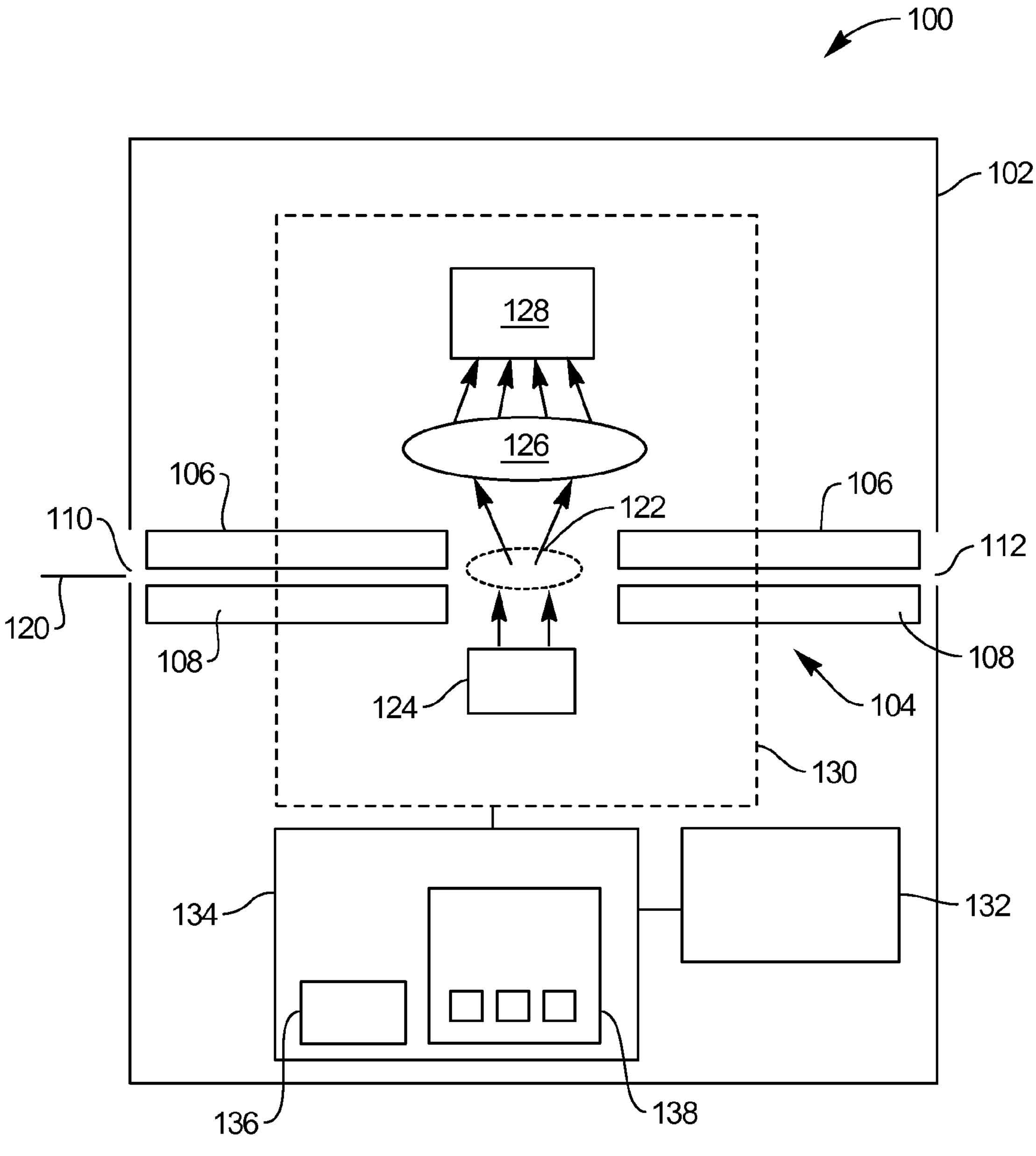

100
102
128
126
106
106
110
122
112
120
108
108
124
104
130
134
132
136
138

Fig 1

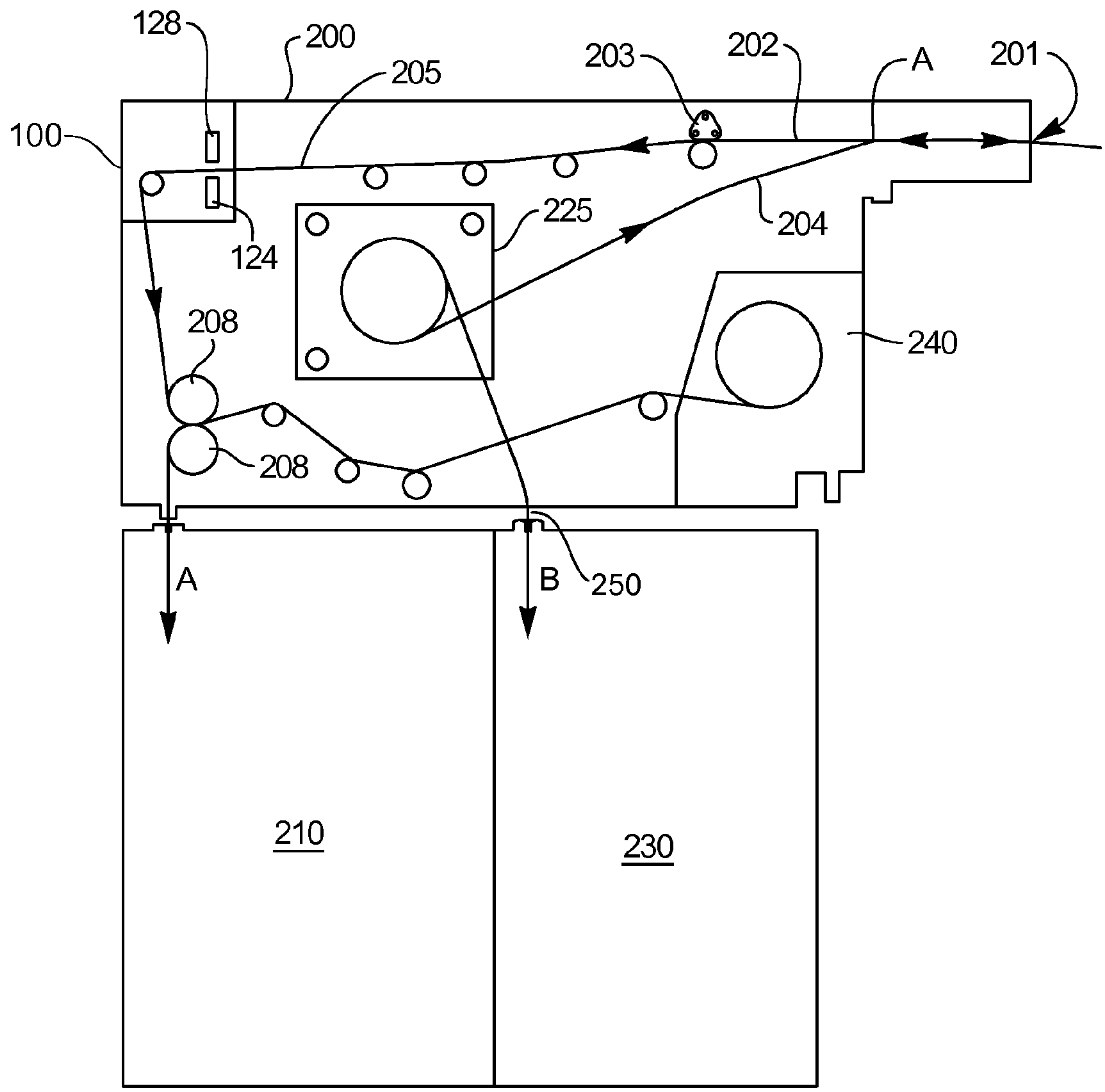

128
200
205
203
202
A
201
100
124
225
204
208
240
208
A
B
250
210
230

Fig 2

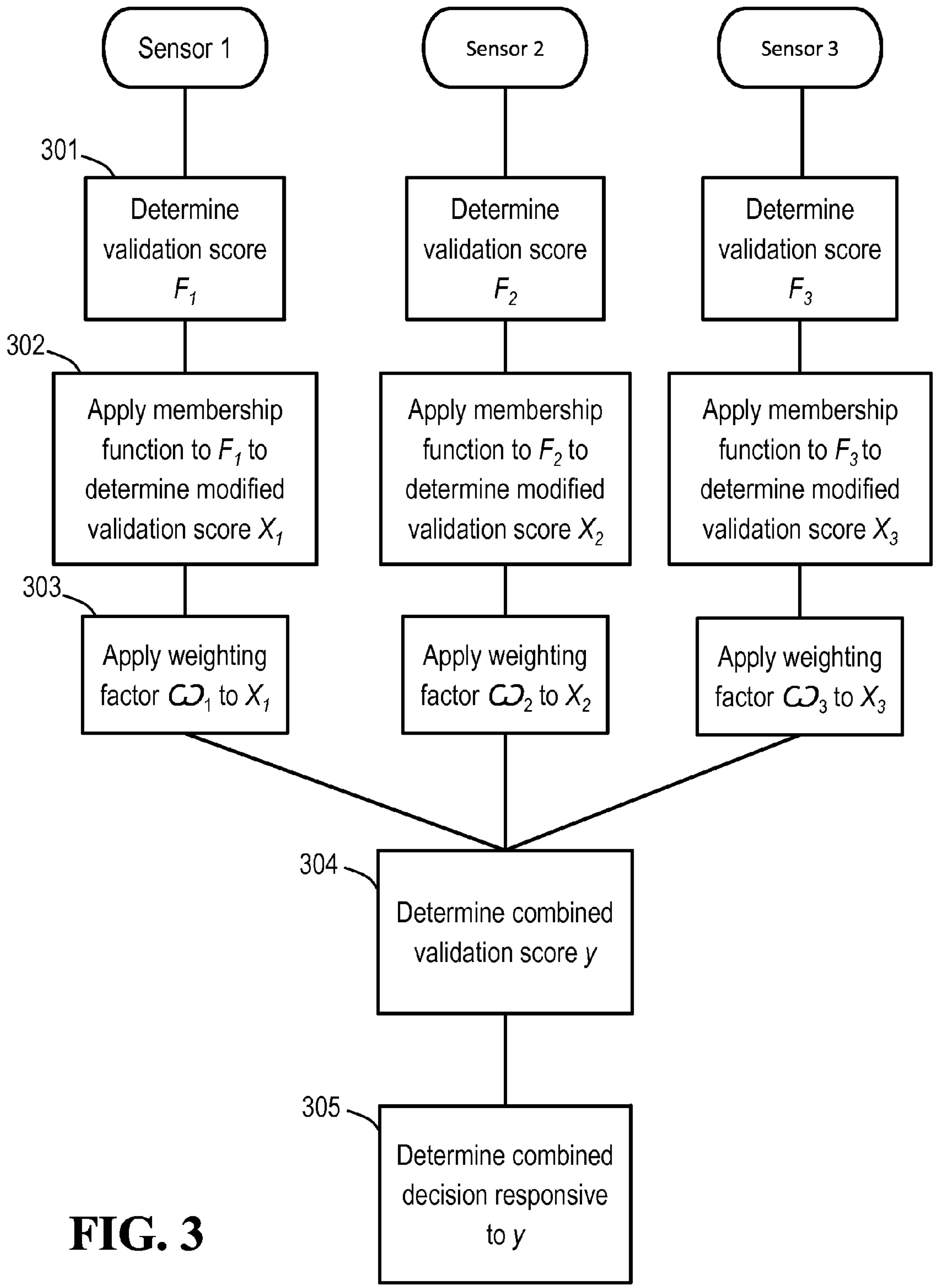

Sensor 1
Sensor 2
Sensor 3
301
Determine validation score F_1
Determine validation score F_2
Determine validation score F_3
302
Apply membership function to F_1 to determine modified validation score X_1
Apply membership function to F_2 to determine modified validation score X_2
Apply membership function to F_3 to determine modified validation score X_3
303
Apply weighting factor ω_1 to X_1
Apply weighting factor ω_2 to X_2
Apply weighting factor ω_3 to X_3
304
Determine combined validation score y
305
Determine combined decision responsive to y

FIG. 3

MEDIA ITEM VALIDATION

FIELD OF THE INVENTION

The present invention relates to media item validation and counterfeit detection. In particular, but not exclusively, the present invention relates to sensing a media item, such as a banknote, and determining if the media item is valid, suspect or counterfeit.

Various situations are known in which media items are transported along different transport pathways in a Self Service Terminal (SST). In typical a SST, such as a banknote depositing Automated Teller Machine (ATM), an ATM customer is allowed to deposit one or more banknotes (without having to place a banknote in a deposit envelope) in a publically accessible, unattended environment. To deposit a banknote, the ATM customer inserts an identification card through a card slot at the ATM, enters a total value of banknotes being deposited, and then inserts the banknote to be deposited through a deposit slot of a banknote acceptor. A transport mechanism receives the inserted banknote and transports the banknote in a forward direction along an infeed transport path to a number of locations within the ATM to process the banknote. One such location includes a validator which examines the banknote, or similar media item such as cheques, vouchers, coupons, giros, or the like, for a number of purposes, including validation and counterfeit detection.

A conventional validator includes a transport mechanism for transporting the banknote along a transport path, a camera located on one side of the transport path to take an image of the banknote and an LED array located on the same side and/or other side of the transport path for illuminating the banknote. The camera may take the form of an optical image sensor and other sensors, such as a magnetic sensor and an ultraviolet sensor, or the like, may also be included in the validator.

Article 6 of ECB (European Central Bank) Council Regulation No. 1338/2001 provides measures necessary for the protection of the Euro against counterfeiting. This article obliges banknote handling machines, especially customer-operated machines such as cash-accepting or cash-recycling ATMs, to be capable of categorising the deposited banknotes as genuine, counterfeit or suspect if recognised. Other countries have either adopted this regulation or published similar regulations in their own currencies, e.g. USA. Therefore, a reliable decision making mechanism in compliance with the above regulation must be established for currency validation in automated cash acceptors and recyclers.

A mechanism is typically required to combine the validation decisions from each of the multiple heterogeneous sensors, such as an optical image sensor, a magnetic sensor and an ultraviolet sensor. A conventional method is by voting, e.g. majority vote or a unanimous vote. However, since this method only considers the final decision of ‘genuine’ or ‘counterfeit’ of each sensor and disregards how confident each sensor believes a banknote to be genuine or counterfeit, the final decision may not be accurate. A requirement therefore exists to improve the accuracy of banknote validation methods and apparatus.

SUMMARY OF THE INVENTION

It is an aim of certain embodiments of the present invention to at least partly mitigate the above-mentioned problems.

It is an aim of certain embodiments of the present invention to provide an accurate, reliable, automatic and simple method of determining if a media item is valid, suspect or counterfeit.

It is an aim of certain embodiments of the present invention to provide a method and apparatus for determining a likelihood that a media item is valid, suspect or counterfeit.

It is an aim of certain embodiments of the present invention to provide a method and apparatus for determining the authenticity of a media item via a number of different sensors, wherein a weighting factor is applied to each sensor to reflect, for example, the importance of each sensor responsive to a particular configuration and/or application.

According to a first aspect of the present invention there is provided a method of validating a media item, comprising:

for each of a plurality of sensors that sense a media item, determining a respective validation score F indicating a likelihood that the sensed media item is valid; and

determining if the media item is valid responsive to the plurality of validation scores.

Aptly, the method further comprises:

comparing each respective validation score F to at least one predetermined threshold τ to generate a threshold result; and

responsive to said threshold result, determining a modified validation score x for each of said sensors.

Aptly, the method further comprises:

combining the modified validation scores x for each sensor to determine a combined validation score y; and

generating a validation result responsive to said combined validation score y to determine if the media item is valid.

Aptly, the method further comprises:

applying a validation rule to said combined validation score y to determine said validation result, wherein said validation result is one of ‘genuine’, ‘suspect’ or ‘counterfeit’.

Aptly, said validation rule comprises:

$$0.75 \le y \le 1 = \text{genuine};$$

$$0.5 \le y < 0.75 = \text{suspect; and}$$

$$0 \le y < 0.5 = \text{counterfeit.} \tag{1}$$

Aptly, the method further comprises:

applying a membership function to each respective validation score F to determine said modified validation score x for each of said sensors, wherein the at least one membership function comprises said at least one predetermined threshold τ.

Aptly, said membership function comprises:

$$\begin{cases} x = 1 & \text{if } F \ge \tau \\ x = \left(1 + \dfrac{(F-\tau)+(F-\tau/2)}{\tau/2}\right)\Big/2 & \text{if } \tau/2 \le F < \tau \\ x = 0 & \text{if } F < \tau/2 \end{cases} \tag{2}$$

Aptly, said membership function comprises:

$$\begin{cases} x = 1, & \text{if } F \le \tau_1 \\ x = \left(1 + \dfrac{(\tau_1 - F)+(\tau_2 - F)}{\tau_2 - \tau_1}\right)\Big/2, & \text{if } \tau_1 < F \le \tau_2\,, \\ x = 0, & \text{if } F > \tau_2 \end{cases} \tag{3}$$

said at least one predetermined threshold τ comprising threshold limits τ_1 and τ_2.

Aptly, the at least one predetermined threshold τ is selectively adjustable.

Aptly, the method further comprises:

applying a weighting factor ω_i to each of the plurality of sensors.

Aptly, a sum of the weighting factors is 1, i.e. $\Sigma\omega_i=1$.

Aptly, each weighting factor is selectively adjustable and/or optimizable.

Aptly, said plurality of sensors comprises an optical image sensor and at least one of a magnetic sensor and an ultraviolet sensor.

Aptly, the media item is a financial media item, such as a banknote or cheque.

According to a second aspect of the present invention there is provided apparatus for validating a media item, comprising:

a plurality of sensors for sensing a media item; and

a processor operable to determine a respective validation score F for each of said sensors, wherein each validation score F indicates a likelihood that a sensed media item is valid, the processor being further operable to determine if the media item is valid responsive to the plurality of validation scores.

Aptly, said plurality of sensors comprises an optical image sensor and at least one of a magnetic sensor and an ultraviolet sensor.

According to a third aspect of the present invention there is provided a document processing module comprising apparatus according to the second aspect of the present invention.

According to a fourth aspect of the present invention there is provided a Self-Service Terminal (SST) comprising a document processing module according to the third aspect of the present invention.

According to a fifth aspect of the present invention there is provided a method of determining the authenticity of a media item, comprising:

determining a respective validation decision for each of a plurality of sensors that sense a media item, wherein each validation decision indicates a degree of authenticity of the media item; and

determining the authenticity of said media item responsive to a combination of the determined validation decisions.

According to a sixth aspect of the present invention there is provided a product which comprises a computer program comprising program instructions for validating a media item via the steps of:

for each of a plurality of sensors, determining a respective validation score F indicating a likelihood that the sensed media item is valid; and

determining if the media item is valid responsive to the plurality of determined validation scores.

Certain embodiments of the present invention may provide a method and apparatus for accurately and reliably determining the likelihood that a media item is valid.

Certain embodiments of the present invention may provide a method and apparatus for indicating whether a sensed media item is absolute counterfeit, absolutely genuine, and anything in between indicating a degree of authenticity.

Certain embodiments of the present invention may provide a method and apparatus to determine the authenticity of a media item by using a plurality of sensors, whilst introducing a weighting factor to each of the sensors reflecting the importance of the different sensors.

BRIEF DESCRIPTION OF DRAWINGS

Embodiments of the present invention will now be described hereinafter, by way of example only, with reference to the accompanying drawings in which:

FIG. **1** illustrates a schematic diagram of a banknote validator according to one embodiment of the present invention;

FIG. **2** illustrates a document processing module including the banknote validator of FIG. **1**; and

FIG. **3** illustrates a flow chart outlining a method of validating a media item according to one embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

In the drawings like reference numerals refer to like parts.

FIG. **1** illustrates a media item validator **100** (in the form of a banknote validator) for implementing, inter alia, a method of validating a banknote according to one embodiment of the present invention. Other types of media item may of course be validated, such as cheques, coupon, giros, tokens, vouchers, or the like.

The banknote validator **100** includes a housing **102** which supports a transport mechanism **104** in the form of a train of pinch rollers **106**, **108** extending from an entrance port **110** to a capture port **112**. The pinch rollers include upper pinch rollers **106** aligned with and spaced apart from lower pinch rollers **108**.

The entrance and capture ports **110**, **112** are in the form of apertures defined by the housing **102**. In use, the capture port **112** would typically be aligned with parts of a depository module.

In use, the pinch rollers **106**, **108** guide a banknote **120** short edge first (or long edge first depending on the transport path set-up) through an examination area **122** defined by a gap between adjacent pinch roller pairs. While the banknote **120** is being conveyed through the examination area **122**, the banknote **120** is illuminated selectively by an illumination source arranged to illuminate across the banknote **120** as it passes through the validator **100**. The illumination source **124** may be one or more of an IR illumination source, a RGB illumination source and a UV illumination source. The illumination source may be located on the opposite side of the transport path to the optical imager **128**, as shown in FIG. **1**, for capturing a transmission image of the banknote where light is passed through the banknote and/or the illumination source may be located on the same side of the transport path as the optical imager **128** for capturing a reflection image of the banknote where light is reflected off reflective features of the banknote. Additional illumination sources and/or sensors are provided for other functions of the banknote validator **100**, such as a magnetic sensor, for example. Different types of sensor are typically provided to detect and determine the validity of corresponding features of a media item, such as a foil strip, hologram, and fluorescent feature of a banknote, for example.

For simplicity, the illumination source **124** is shown in FIG. **1** as an infrared LED array, such that when the infrared LEDs **124** are illuminated, the emitted infrared radiation is incident on an underside of the banknote **120** and an optical lens **126** focuses light transmitted through the banknote **120** to the optical imager **128** (in this embodiment a CCD Contact Image Sensor (CIS). This provides a transmitted infrared channel output from the optical imager **128**. In this embodiment, the optical imager comprises an array of elements, each element providing an 8-bit value of detected intensity. The CIS **128** in this embodiment is 200 dots per inch sensor but the outputs are averaged, in this embodiment, so that 25 dots per inch are provided. It will be understood that alternatively or in addition to an infrared LED array, other illumination sources are envisaged such as an RGB output device and UV illumination sources for capturing reflection and/or transmission image types of a banknote.

The illumination source **124**, lens **126** and imager **128** comprise an image collection component **130**.

The banknote validator **100** includes a data and power interface **132** for allowing the banknote validator **100** to transfer data to an external unit, such as an ATM (as shown in FIG. **2**), a media depository (not shown), or a computer (not shown), and to receive data, commands, and power therefrom. The banknote validator **100** will typically be incorporated into a media depository, which would typically be incorporated into an ATM.

The banknote validator **100** also includes a controller **134** including a Digital Signal Processor (DSP) **136** and an associated memory **138**. The controller **134** controls the pinch rollers **106**, **108** and the image collection components **130** (including energising and de-energising the illuminating source **124**). The controller **134** also collates and processes data captured by the image collection component **130**, and communicates this data and/or results of any analysis of this data to the external unit via the data and power interface **132**. The controller **134** also receives the illumination transmission data from the optical imager **128**, for example.

As illustrated in FIG. **2**, a document processing module **200** has an access mouth **201** through which incoming cheques and/or banknotes are deposited or outgoing cheques are dispensed. This mouth **201** is aligned with an infeed aperture in the ATM. A bunch of one or more banknotes or cheques is input or output via the infeed aperture of the ATM. Aptly, a bunch of a hundred items or more can be received/dispensed. Incoming banknotes or cheques follow a first transport path **202** away from the mouth **201** in a substantially horizontal direction from right to left as shown in FIG. **2**. The first transport path **202** is also referred to as the infeed path. The banknotes or cheques then pass through a feeder/separator **203** and along another pathway portion **205** which is also substantially horizontal and right to left. The banknotes or cheques then individually enter the validator module of FIG. **1** which includes the illumination source **124** and imager **128**.

The cheques or banknotes are then directed substantially vertically downwards to a point between two nip rollers **208**. These nip rollers co-operate and are rotated in opposite directions with respect to each other to either draw deposited cheques or banknotes inwards (and urge those cheques towards the right hand side in FIG. **2**), or during another mode of operation, the rollers can be rotated in an opposite fashion to direct processed cheques or banknotes downwards in the direction shown by arrow A in FIG. **2** into a cheque bin **210**. Incoming cheques or banknotes which are moved by the nip rollers **208** towards the right can either be diverted upwards (in FIG. **2**) into a re-buncher unit **225**, or downwards in the direction of arrow B in FIG. **2** into a cash bin **230**, or to the right hand side shown in FIG. **2** into an escrow **240**. Cheques or banknotes from the escrow can be directed to the re-buncher **225** or downwards into the cash bin **230**. Cheques or banknotes can be reprocessed or returned to a customer via a further transport path **204**, also known as the return path.

In accordance with certain embodiments of the present invention, the imager **128** obtains a digital image of a banknote **120** located on the transport path **205**. The digital image of the banknote is then used to extract certain elements of the image and compare the same with a stored database to determine a likelihood of authenticity of the banknote. A magnetic sensor of the validation module senses a magnetic feature of the banknote to determine the likelihood that the sensed media item is valid. Furthermore, an ultraviolet sensor further determines the likelihood that the sensed media item is valid based on a fluorescent element of the banknote. These sensors are illustrated in FIG. **3**. It will be understood that any number and type of sensors may be utilised in accordance with the present invention.

As shown in step **301** of FIG. **3**, a validation score F is determined for each of the individual sensors by controller **134**. A membership function is then applied (at step **302**) to each respective validation score F to determine a modified validation score x for each of said sensors, wherein the membership function comprises at least one predetermined threshold τ:

$$\begin{cases} x = 1 & \text{if } F \geq \tau \\ x = \left(1 + \dfrac{(F-\tau)+(F-\tau/2)}{\tau/2}\right)\Big/2 & \text{if } \tau/2 \leq F < \tau \\ x = 0 & \text{if } F < \tau/2 \end{cases} \quad (1)$$

Depending on the type of sensor, the predetermined threshold τ may be a single threshold (as shown in equation (1) above) or may comprise upper and lower threshold limits, τ_1 and τ_2, as shown in membership function (2) below:

$$\begin{cases} x = 1, & \text{if } F \leq \tau_1 \\ x = \left(1 + \dfrac{(\tau_1-F)+(\tau_2-F)}{\tau_2-\tau_1}\right)\Big/2, & \text{if } \tau_1 < F \leq \tau_2 \\ x = 0, & \text{if } F > \tau_2 \end{cases} \quad (2)$$

An individual sensor applying only one level of the threshold τ for authenticity determination can only distinguish between genuine and counterfeit, whilst an individual sensor applying two level thresholds τ_1 and τ_2 for authenticity determination can distinguish between genuine, suspect and counterfeit.

Following membership functions (1) or (2) for a particular sensor, each validation score F for a respective sensor can be normalised into a modified validation score x of from 0 to 1, and therebetween, with 0 indicating absolute counterfeit, 1 indicating absolutely genuine, and anything in between indicating a degree of authenticity for that particular sensor. The above membership functions (1) and (2) introduce ‘fuzziness’, or a degree of fuzzy logic, to each validation score for a respective sensor, i.e. a degree of authenticity or suspect factor for each sensor, rather than a ‘hard’ voting-based method as conventionally used. It will be understood that membership functions (1) and (2) are examples of fuzzy logic membership functions. Any other membership functions may be envisaged depending on a particular application.

The at least one predetermined threshold τ (or T_1 and τ_2) may be selectively adjustable for a particular configuration and/or application. Such thresholds may be adjusted according to, for example, a banking establishment’s tolerance level for the performance-risk trade-off, or according to specific requirements for a particular country and/or currency. Such thresholds may also be determined for each currency automatically at the training stage by assessing the data of a large quantity of banknotes from the same class (same currency, series, denomination and orientation) via an intelligent machine learning algorithm.

Furthermore, the respective validation scores F may be weighted (as shown at step **303**) dependent on a respective sensor. For example, a validation score from an optical sensor may be of greater importance than the validation score from a magnetic and/or ultraviolet sensor, for example, depending on a particular configuration/application of the validation module. A weighting factor ω_i applied to each sensor score may be selectively adjustable and/or optimizable. Adjustment of a weighting factor may be useful according to a security feature design for a particular currency. For example, if there is no magnetic feature on a particular currency to be validated, a corresponding weighting factor for the magnetic sensor of the validator module can be set to zero. Furthermore, the weighting factors may be optimized according to TAR (true accept rate of genuine banknotes) and/or FAR (false accept rate of counterfeit banknotes) performance targets. As will be understood in the art, TAR and FAR are statistics used to measure the acceptance performance when performing a verification task, such as the percentage of times a banknote validator correctly or incorrectly determines the validity of a genuine or counterfeit banknote respectively. It is possible to use genetic algorithms (or evolutionary algorithms) to intelligently optimise the weighting factors, where the TAR and FAR statistics can be used to easily form the fitness function that is required for operating a genetic algorithm.

A sum of the weighting factors $\Sigma\omega_i$ equals 1 so that, for example, an optical sensor may have a weighting factor of 0.5, and a magnetic sensor and a UV sensor may each have a weighting factor of 0.25.

A sum of the weighted modified validation scores x_i is then determined (at step **304**) following equation (3) below:

$$y = \sum_i \omega_i x_i \tag{3}$$

wherein, y is a combined validation score for a particular banknote based on the individual weighted validation scores x_i for the different sensors.

This combined validation score can then be used (at step **305**) to determine a combined decision for the media item by applying the following membership functions to the combined validation score:

$$0.75 \le y \le 1 = \text{genuine};$$

$$0.5 \le y < 0.75 = \text{suspect; and}$$

$$0 \le y < 0.5 = \text{counterfeit}. \tag{4}$$

It will be understood that the parameters in (4) are for example only and they can be adjusted according to the requirements of a banking establishment and/or field performance, for example. It will also be understood that although three different sensors are described for the purposes of certain embodiments of the present invention, the weighting factors can be used for combining any number and type of sensor sources. Aptly, the sum of the weighting factors is 1. The present invention according to certain embodiments of the present invention may therefore provide a method and apparatus for normalising and introducing fuzzy logic to each of a plurality of sensor validation scores and then combining the validation scores to determine a degree of authenticity of a media item. Certain embodiments of the present invention may provide a unified framework to combine decisions from multiple heterogeneous sensors. The introduction of fuzzy logic provides a more reliable and accurate combined decision than conventional voting-based combination methods. A method in accordance with certain embodiments of the present invention may be applied to combine any number and type of sensors for validating a media item. The present invention according to certain embodiments may provide a method and apparatus which complies with the ECB Article 6 regulatory requirements.

Throughout the description and claims of this specification, the words “comprise” and “contain” and variations of them mean “including but not limited to” and they are not intended to (and do not) exclude other moieties, additives, components, integers or steps. Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

Features, integers, characteristics or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith. All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of the features and/or steps are mutually exclusive. The invention is not restricted to any details of any foregoing embodiments. The invention extends to any novel one, or novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

The reader’s attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

What is claimed is:

1. A method of validating a media item, comprising:

for each of a plurality of sensors that sense a media item, determining, by a processor of a media validator, a respective validation score F indicating a likelihood that the sensed media item is valid;

determining, by the processor, if the media item is valid responsive to the plurality of validation scores by using a fuzzy logic approach rather than a voting-based approach;

comparing each respective validation score F to at least one predetermined threshold τ to generate a threshold result; and

responsive to said threshold result, determining a modified validation score x for each of said sensors; and

applying a membership function to each respective validation score F to determine said modified validation score x for each of said sensors, wherein the at least one membership function comprises said at least one predetermined threshold τ, wherein said membership function comprises:

$$\begin{cases} x = 1 & \text{if } F \ge \tau \\ x = \left(1 + \dfrac{(F-\tau)+(F-\tau/2)}{\tau/2}\right)\Big/2 & \text{if } \tau/2 \le F < \tau \\ x = 0 & \text{if } F < \tau/2 \end{cases}.$$

2. The method as claimed in claim 1, further comprising: combining the modified validation scores x for each sensor to determine a combined validation score y; and generating a validation result responsive to said combined validation score y to determine if the media item is valid.

3. The method as claimed in claim 2, further comprising: applying a validation rule to said combined validation score y to determine said validation result, wherein said validation result is one of 'genuine', 'suspect' or 'counterfeit'.

4. The method as claimed in claim 3, wherein said validation rule comprises:

$$0.75 \leq y \leq 1 = \text{genuine};$$

$$0.5 \leq y < 0.75 = \text{suspect; and}$$

$$0 \leq y < 0.5 = \text{counterfeit}.$$

5. The method as claimed in claim 1, further comprising: applying a weighting factor ω to each of the plurality of sensors.

6. The method as claimed in claim 5, wherein a sum of the weighting factors is 1.

7. The method as claimed in claim 5, wherein each weighting factor is selectively adjustable and/or optimizable.

8. The method as claimed in claim 1, wherein said plurality of sensors comprises an optical image sensor and at least one of a magnetic sensor and an ultraviolet sensor.

9. A method of validating a media item, comprising:
for each of a plurality of sensors that sense a media item, determining, by a processor of a media validator, a respective validation score F indicating a likelihood that the sensed media item is valid;
determining, by the processor, if the media item is valid responsive to the plurality of validation scores by using a fuzzy logic approach rather than a voting-based approach;
comparing each respective validation score F to at least one predetermined threshold τ to generate a threshold result; and
responsive to said threshold result, determining a modified validation score x for each of said sensors; and
applying a membership function to each respective validation score F to determine said modified validation score x for each of said sensors, wherein the at least one membership function comprises said at least one predetermined threshold τ, wherein said membership function comprises:

$$\begin{cases} x = 1, & \text{if } F \leq \tau_1 \\ x = \left(1 + \dfrac{(\tau_1 - F) + (\tau_2 - F)}{\tau_2 - \tau_1}\right)\Big/2, & \text{if } \tau_1 < F \leq \tau_2 \\ x = 0 & \text{if } F > \tau_2 \end{cases},$$

,said at least one predetermined threshold t comprising threshold limits τ_1 and τ_2.

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